Original Article

Transverse Strength of Repaired Denture Base Material with Wire and Two Auto Polymerized Acrylic Resin

F. Golbidi [1,2], T. Mousavi [3]

[1] Assistant Professor, Department of Prosthodontics, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
[2] Assistant Professor, Torabinejad Dental Research Center, Isfahan University of Medical Sciences, Isfahan, Iran
[3] Dentist, Private Practice

Abstract:

Objective: The purpose of this study was to evaluate the transverse strength of one brand of denture base material repaired with two autopolymerized acrylic resins with and without wire reinforcement.

Materials and Methods: Eighty samples ($2.5\times10\times65$ mm^3) were fabricated and divided into five groups. The control group was left intact. Groups B and D specimens were repaired with autopolymerizing acrylic resins. Groups A and C specimens were repaired with metal wire and autopolymerizing acrylic resins. After 48 hours of storage at 37°C, the transverse strength of the specimens was measured with a universal testing machine. Data were analyzed by one way ANOVA and Duncan test (α=0.05).

Results: Significant differences were found between the control group and the other experimental groups ($P<0.05$). Among experimental groups, group D showed the highest transverse strength with the mean value of 40.2 (SD=11.8) MPa while group B present the lowest transverse strength of 28.4 (SD=5.4) MPa. The difference between the transverse strength of group D and the other groups was statistically significant ($P<0.05$).

Conclusion: In wire reinforced groups, there was no significant difference between two types of acrylic resin ($P=0.93$), however in repaired groups without wire, the type of acrylic resin generates a significant difference in the transverse strength of the repaired specimens ($P<0.05$). The application of wire significantly reduces the transverse strength of the Meliodent repaired groups ($P<0.05$), however the changes occurred in transverse strength of the Acropars repaired groups was not statistically significant ($P=0.28$).

Key Words: Acrylic Resins; Dental Stress Analysis; Denture Repair; Denture Bases; Methylmethacrylate; Orthodontic Wires

Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran (2007; Vol: 4, No.4)

Corresponding author:
F. Golbidi, Department of Prosthodontics, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
fgolbidi@yahoo.com

Received: 15 October 2006
Accepted: 16 May 2007

INTRODUCTION

Denture fracture is a common problem in Prosthodontics [1]. The final objective of denture repair is to prevent further fractures. Autopolymerized [2], heat polymerized [3], visible light polymerized [2,3,4], and microwave polymerized acrylic resins [3,5-7] have been used to repair fractured dentures. Although various materials have been proposed for repairing fractured denture bases, the use of autopolymerizing resin is the most popular [6]. It should be mentioned that repairing with autopolymerized resin is much weaker than the originally used heat polymerized denture resin [6]. Attempts have been made to improve the mechanical properties of the repaired sites by changing either the joint surface contours [8,9], the processing methods [9-11], optimizing the distance between repaired sites [8], by using surface treatment [12-14], or reinforcing

Table 1. Results of transverse strength.

Groups	Transverse strength (Mpa)				P Value
	Mean	SD	lower bound (95% CI)	upper bound (95% CI)	
A-Acropars with wire	31.8	7.0	28.1	35.5	
B-Acropars without wire	28.4	5.4	25.5	31.3	
C-Meliodent with wire	32.1	7.9	27.8	36.3	P<0.05
D-Meliodent without wire	40.2	11.8	34	46.5	
E-Control group	113.9	11.0	108.0	119.8	

materials such as metal wires [6,15-18], polymethyl methacrylate [19], aramide or nylon [20] fibers. The aim of present study was to compare the transverse strength of repaired acrylic specimens with Acropars (Marlic Co. Tehran, Iran) and Meliodent resins (Bayer dental, Bayer UK limited, UK), and to evaluate the effectiveness of metal wire reinforcement on these repairs.

MATERIALS AND METHODS

In this experimental study, four aluminum master dies with the dimensions of 2.5×10×65 mm^3 were prepared. The master dies were invested in denture flasks with dental stone (Hinrizit stone,Ernst Hinrichs Gmbh, Germany). Eighty samples were prepared with Meliodent acrylic resin (Bayer dental, Bayer UK limited, UK) using conventional compression molding technique. All specimens were processed according to the manufacturer's recommendations. The specimens were divided into four experimental groups; each comprised of 16 specimens (Table 1), and a control group (E) consisted of intact acrylic samples. The specimens in groups B and D were cut in the middle with a non-stop device (Krupp Dental, Dentarapid) and fixed in an open-ended mold, so that a 3-mm gap was present between the two cut pieces. These specimens were repaired with a free flowing mixture of autopolymerized Acropars and Meliodent acrylic resin in group B, and D respectively.

In order to reinforce specimens with metal wire, (Groups A and C), first an additional 30×2.5 mm central channel was prepared in the middle of acrylic specimens with a fissure bur. Then these specimens were cut in the middle, fixed in a stone mold, and 20×0.8 mm copper wires were placed. These specimens were repaired using a free flowing mixture of autopolymerized Acropars (in group A) and Meliodent acrylic resins (in group C). All the autopolymerized acrylic resins were mixed and polymerized according to the manufacturer's recommendations. Final finishing was performed using a #400 sandpaper and all samples returned to their original dimensions. Finally, the repaired specimens were stored in distilled water at 37°C for 48 hours prior to testing.

The specimens were examined using a three-point bending test with a universal testing machine (Instron 4301, Instron Corp, Canton, Mass) at a constant cross head speed of 5 mm/min. The span for the three-point deflection test was 50 mm. The fracture force was recorded in Newton. The transverse strength of each specimen was calculated using the following equation [21]:

$$S = \frac{3f\ L}{2b\ d^2}$$

Where S=transverse strength (MPa), f=fracture force (N), L=distance between supports (mm), b=specimen width (mm) and d=specimen thickness (mm). Mean values and standard deviations were calculated for the transverse strength. Collected data were analyzed using one-way analysis of variance and Duncan test. P-values less than 0.05 were considered statistically significant.

RESULTS

The transverse strength of all specimens is presented in the Table 1. Results displayed that among the repaired groups, group D (Meliodent without wire) had the highest and group B (Acropars without wire) had the lowest transverse strength which was 40.2 (SD=11.8) MPa and 28.4 (SD=5.4) MPa, respectively.

Statistical analysis by Duncan test revealed that the difference among transverse strength of groups A, B, and C was not significant (P=0.07); however the difference between group D and other groups was significant (P<0.05).

DISCUSSION

Denture fracture often occurs at the interface junction of the original base and repair materials, rather than within these materials [13]. The purpose of this study was to compare the transverse strength of two acrylic resins (Acropars and Meliodent) when used as repairing materials with or without metal wire reinforcement.

The results indicated that the transverse strength decreases consecutively in the group E, D, C, A, and B. The results showed that in the wire reinforced groups, there was not statistically significant difference between the type of acrylic resin used for the repair (P=0.93). However without wire reinforcement, the type of acrylic resin created a significant difference in the transverse strength (P<0.05). Using wire reinforcement in the Acropars group slightly increased the transverse strength, however this difference was not significant (P=0.28).

In separate surveys Zissis et al [22], Darbar et al [23], and Valittue and Lassila [17,18] reported that the presence of metal wires in repaired prosthesis strengthened the acrylic resin which was similar to the results of the Acropars-repaired specimens in our study. In contrast, wire reinforcement in Meliodent repaired groups reduced the transverse strength of the repaired specimens, in a way that group D specimens had a significant difference with groups A, B, and C. This may be due to the poor potential attachment between acrylic resin and non-acrylic materials.

The important effective factors for variation of transverse strength in repaired samples are the joint surface contours [8,9], processing methods [9,10,11], distance between repaired sites [8], type of wire [6,15-18], repairing acrylic resin [9,11,24], the amount of residual stress [25,26] and porosity [21,27] in the repaired site. Therefore, these parameters should be studied carefully for Acropars acrylic resin.

In the present study, all the repaired specimens fractured adhesively and failure occurred between the parent and repaired resin. As a result, the most important factor for the success of denture repair is the adhesion between the fractured sites and the repair material; stronger adhesive bond reduces the stress concentration and increases the strength of repaired unit [31].

There are numerous studies and methods concerning the strengthening of PMMA or enhancing the adhesion between metal and acrylic resins. These methods include metal surface sandblasting [17,18], chemical surface treatment [12-14], application of adhesive resins [16,28-30], the use of microwave radiation [3,5-7] or strengthening materials such as glass [6,15,17,20,31,32], metal wires [6,15-18], polymethacrylate [19], and aramide or nylon [20] fibers.

Etching the repaired surfaces with chemical etchants was suggested by some investigators [28]. Chemical surface treatment creates superficial crack propagation, as well as the formation of numerous pits approximately 2μm in diameter. This surface morphologic change may enhance the mechanical retention between a fractured surface and repaired acrylic resin. This may be attributed to superior adhesion because of monomer infiltration into the pits and cracks [28]. Further investigation regarding these reinforcing methods is suggested

for Acropars acrylic resin.
Since the clinical conditions in this study were not simulated with thermomechanical cycling and repetitive mechanical stress, further investigations are necessary to evaluate the bonding under more closely simulated clinical conditions.

CONCLUSION

Within the limitations of the laboratory testing conditions in this study, the following conclusions were drawn:
Repair by the Meliodent acrylic resin is stronger than that of Acropars. Resin repair with Acropars acrylic resin produces better results with metal wire reinforcement, and the repair with Meliodent acrylic resin has a better result without metal wire reinforcement.

ACKNOWLEDGMENT

The authors would like to thank Torabinejad Dental Research Center, Isfahan School of Dentistry for their kind assistance.

REFERENCES

1-Vallittu PK, Lassila VP, Lappalainen R. Evaluation of damage to removable dentures in two cities in Finland. Acta Odontol Scand 1993 Dec;51(6): 363-9.
2-Dar-Odeh NS, Harrison A, Abu-Hammad O. An evaluation of self-cured and visible light-cured denture base materials when used as a denture base repair material. J Oral Rehabil 1997 Oct;24(10): 755-60.
3-Polyzois GL, Handley RW, Stafford GD. Repair strength of denture base resins using various methods.Eur J Prosthodont Restor Dent 1995 Jun;3(4): 183-6.
4-Lewinstein I, Zeltser C, Mayer CM, Tal Y. Transverse bond strength of repaired acrylic resin strips and temperature rise of dentures relined with VLC reline resin. J Prosthet Dent 1995 Oct;74(4): 392-9.
5-Yunus N, Harrison A, Huggett R. Effect of microwave irradiation on the flexural strength and residual monomer levels of an acrylic resin repair material. J Oral Rehabil 1994 Nov;21(6):641-8.
6-Polyzois GL, Tarantili PA, Frangou MJ, Andreopoulos AG. Fracture force, deflection at fracture, and toughness of repaired denture resin subjected to microwave polymerization or reinforced with wire or glass fiber. J Prosthet Dent 2001 Dec; 86(6):613-9.
7-Rached RN, Powers JM, Del Bel Cury AA. Repair strength of autopolymerizing, microwave, and conventional heat-polymerized acrylic resins. J Prosthet Dent 2004 Jul;92(1):79-82.
8-Harrison WM, Stansbury BE. The effect of joint surface contours on the transverse strength of repaired acrylic resin. J Prosthet Dent 1970 Apr; 23(4):464-72.
9-Ward JE, Moon PC, Levine RA, Behrendt CL. Effect of repair surface design, repair material, and processing method on the transverse strength of repaired acrylic denture resin. J Prosthet Dent 1992 Jun;67(6):815-20.
10-Ogawa T, Hasegawa A. Effect of curing environment on mechanical properties and polymerizing behaviour of methyl-methacrylate autopolymerizing resin. J Oral Rehabil 2005 Mar;32(3): 221-6.
11-Ganzarolli SM, de Mello JA, Shinkai RS, Del Bel Cury AA. Internal adaptation and some physical properties of methacrylate-based denture base resins polymerized by different techniques. J Biomed Mater Res B Appl Biomater 2007 Jul;82(1): 169-73.
12-Shen C, Colaizzi FA, Birns B. Strength of denture repairs as influenced by surface treatment. J Prosthet Dent 1984 Dec;52(6):844-8.
13-Sarac YS, Sarac D, Kulunk T, Kulunk S. The effect of chemical surface treatments of different denture base resins on the shear bond strength of denture repair. J Prosthet Dent 2005 Sep;94(3): 259-66.
14-Shimizu H, Ikuyama T, Hayakawa E, Tsue F, Takahashi Y. Effect of surface preparation using ethyl acetate on the repair strength of denture base resin. Acta Odontol Scand 2006 Jun;64(3):159-63.
15-Nagai E, Otani K, Satoh Y, Suzuki S. Repair of

denture base resin using woven metal and glass fiber: effect of methylene chloride pretreatment. J Prosthet Dent 2001 May;85(5):496-500.
16-Polyzois GL, Andreopoulos AG, Lagouvardos PE. Acrylic resin denture repair with adhesive resin and metal wires: effects on strength parameters. J Prosthet Dent. 1996 Apr;75(4):381-7.
17-Vallittu PK, Lassila VP. Reinforcement of acrylic resin denture base material with metal or fibre strengtheners. J Oral Rehabil 1992 May; 19(3):225-30.
18-Vallittu PK, Lassila VP. Effect of metal strengthener's surface roughness on fracture resistance of acrylic denture base material. J Oral Rehabil 1992 Jul;19(4):385-91.
19-Jagger DC, Alshumailin YR, Harrison A, Rees JS. The effect of the addition of poly (methyl methacrylate) fibres on the transverse strength of repaired heat-cured acrylic resin. J Oral Rehabil 2003 Sep;30(9):903-8.
20-John J, Gangadhar SA, Shah I. Flexural strength of heat-polymerized polymethyl methacrylate denture resin reinforced with glass, aramid, or nylon fibers. J Prosthet Dent. 2001 Oct;86(4): 424-7.
21-Craig RG. Restorative dental material. 11th ed. St Louis: Mosby; 2002. p. 636-66.
22-Zissis AI, Polyzois GL, Yannikakis SA. Repairs in complete dentures: results of a survey. Quintessence Dental Technol 1997;20:149-55.
23-Darbar UR, Huggett R, Harrison A. Denture fracture--a survey. Br Dent J 1994 May 7;176(9): 342-5.
24-Jagger DC, Jagger RG, Allen SM, Harrison A. An investigation into the transverse and impact strength of "high strength" denture base acrylic resins. J Oral Rehabil 2002 Mar;29(3):263-7.
25-Ruyter IE, Svendsen SA. Flexural properties of denture base polymers. J Prosthet Dent 1980 Jan; 43(1):95-104.
26-Beyli MS, von Fraunhofer JA. Repair of fractured acrylic resin. J Prosthet Dent 1980 Nov; 44(5):497-503.
27-Anusavice KJ. Phillip's science of dental material. 11th ed. St Louis: WB Saunders Co; 2003. p. 91-2, 721-56.
28-Gaw DA, Mahood M. Micromechanical and chemical techniques for attaching acrylic resin to Cobalt-Chromium alloy. J Dent Res 1989 Apr; 68(4):590.
29-Rothfuss LG, Hokett SD, Hondrum SO, Elrod CW. Resin to metal bond strengths using two commercial systems. J Prosthet Dent 1998 Mar; 79(3):270-2.
30-Polyzois GL, Andreopoulos AG, Lagouvardos PE. Acrylic resin denture repair with adhesive resin and metal wires: effects on strength parameters. J Prosthet Dent 1996 Apr;75(4):381-7.
31-Stipho HD. Repair of acrylic resin denture base reinforced with glass fiber. J Prosthet Dent 1998 Nov;80(5):546-50.
32-Keyf F, Uzun G. The effects of glass fiber reinforcement at different concentrations on the transverse strength, deflection and modulus of elasticity of a provisional fixed partial denture resin. J Biomater Appl 2001 Oct;16(2):149-56.